

## Standard for Enhanced Swale

### Definition

A constructed watercourse shaped or graded in earth materials and stabilized with site suitable vegetation, for the safe conveyance and water quality improvement of storm runoff.

### Purpose

To provide for the conveyance and water quality improvement of stormwater runoff without damage by erosion or flooding. An enhanced swale may be constructed as a grassed parabolic channel with gravel check dams perpendicular to the center line, or by creating a bioretention zone in the subsurface, or with both components.

### Conditions Where Practice Applies

This practice applies to developing sites with contributing drainage areas **less than 25 acres**. Channel velocity can not exceed 1.5 fps. Swale channel slope shall not exceed 10%. *This practice is not appropriate if maintenance of the grass channel can or will not be performed adequately.*

**Note :** Grass waterways used solely for stormwater conveyance from larger contributing drainage areas should be designed according to Standards for Soil Erosion and Sediment Control in New Jersey.

### Enhanced Swale Design Criteria:

#### 1. Swale capacity

Peak discharge volumes shall be determined by one of the following procedures:

- a. Rational Method – for peak discharge of uniform drainage areas as outlined in Technical Manual for Land Use Regulation Program, Bureau of Inland and Coastal Regulations Stream Encroachment Permits, Trenton, N.J. September 1997 or subsequent editions.
- b. USDA-NRCS Technical Release No. 55 or Technical Release No. 20.
- c. U.S. Army Corps of Engineers HEC-1.

Minimum capacity and maximum velocity shall be based on the 10 year frequency rainfall event, unless a larger runoff volume storm must be conveyed for reasons of safety, or compatibility with other stormwater management measures.

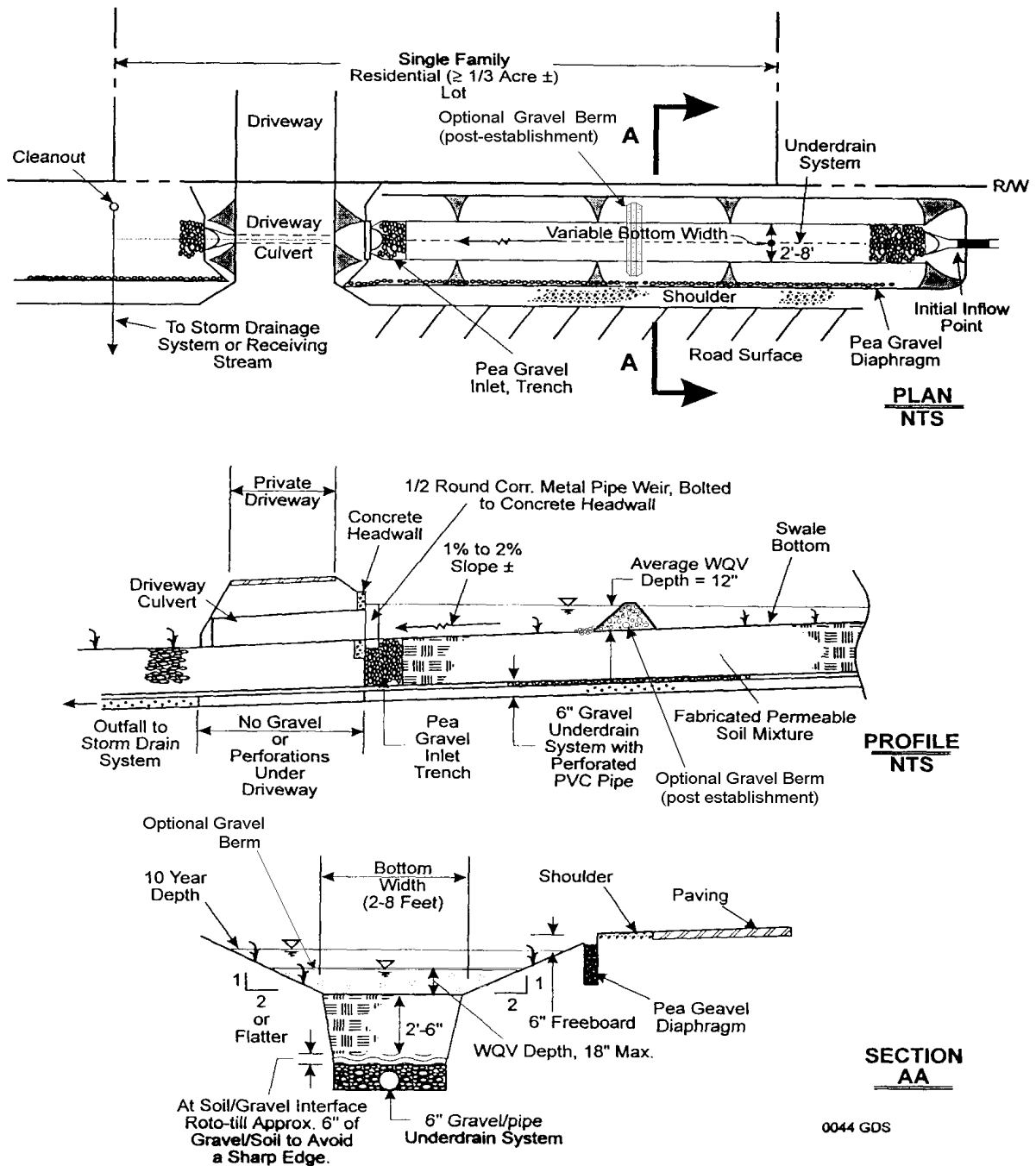


Figure 1. Enhanced Swale typical design

Adapted from: Design of Stormwater Filtering Systems. Center for Watershed Protection

## 2. Velocity

The maximum allowable velocity for design flow will be determined by the most erodible soil texture exposed and the type of vegetation expected and maintained in the channel. As a stable design, the swale will meet the following allowable velocity criteria and shall not be designed within 10% of critical flow .

**Table 1.**  
**Maximum Allowable Velocities by Soil Texture**

Soil Texture	Maximum Allowable Velocity (fps)	
	Seeded <sup>1</sup>	Sodded <sup>2</sup>
Sand	2.0	3.0
Silt loam, sandy loam, loamy sand, loam	2.0	3.0
Silty clay loam, sandy clay loam	2.5	4.0
Clay, clay loam, sandy clay, silty clay	3.0	5.0

Note: maximum allowable velocities are based on flow of clear water.

**Table 2.**  
**Classification of Flexible Channel Liners by  
State of Texas Dept. of Transportation**

Class 2 Designation <sup>3</sup>	Allowable Shear Stress	Allowable Soil Loss <sup>4</sup> (soil deformation, in.)	Incremental Velocity Increase
Type E	0 to 2	0.453	1.0
Type F	0 to 4	0.394	1.5
Type G	0 to 6	0.394	2.0
Type H	0 to 8	0.315	3.0

## Vegetative Retardance Factors and Manning's n Value

The minimum capacity and maximum velocity shall be determined by using the appropriate vegetative retardance factors listed below. USDA-NRCS Agricultural Handbook

<sup>1</sup> Maximum allowable velocities for channels stabilized by seeding may be increased according to the type of Flexible Channel Liner used as shown in the following table. These velocities may be added to the allowable velocities shown above, except for sands.

<sup>2</sup> On well to excessively-drained soils, most cool season sod grasses will not survive without continued irrigation. Placement of sod in such areas must be approved by the Soil Conservation District.

<sup>3</sup> Designations defined by Texas Department of Transportation Hydraulics and Erosion Control Laboratory Field Performance Testing of Selected Erosion Control Products, 1995 Evaluation Cycle.

<sup>4</sup> Distance measures loss of contact between liner and soil

No. 667, Stability Design of Grass-Lined Open Channels, may also be used to design enhanced swales based on tractive stress. A computer program, developed by NRCS in Ohio, is also available to automate the design procedure.

Appropriate vegetative retardance factors:

- a. Minimum for capacity – D
- b. Maximum for allowable velocity – E

Tables to select channel dimensions are available in Standards for Soil Erosion and Sediment Control in New Jersey.

Dimensions:

The dimensions of the swale will be based on:

- a. the minimum required for capacity
- b. the channel slope
- c. the maximum permissible velocity
- d. the vegetation
- e. the soil
- f. ease of crossing and maintenance
- g. moisture or bedrock related site conditions

- In any case, the minimum top width of a swale will be 15 feet.
- The maximum top width will be 30 feet.
- The cross section of the channel shall be parabolic in all cases. Cross sections and gradient profiles shall be submitted on the Soil Erosion and Sedimentation Control Plan, submitted to the Soil Conservation District.
- The outlet of the swale must be non-erosive for the 10-year frequency design storm.

Drainage

In areas with continual low flow, high water table, or periodic ground water seepage problems, additional components shall be built into the swale. Perforated plastic underdrains, stone centers, parallel curtain drains, or other subsurface drainage methods are to be provided. A minimum drainage coefficient of  $\frac{1}{2}$  inch in 24 hours is to be used for underdrain design. An open joint storm drain may be used to serve the same purpose and also handle frequently occurring storm runoff, base flow, or snowmelt. The storm drain shall be designed to handle base flow, snowmelt, or the runoff from at least a one year frequency storm, whichever is greater.

## Stone Centers

Swales constructed with stone centers are more costly, but provide several significant advantages over seeded ones. First, the stone center (actually the middle third of the cross section) can handle low flows without erosion; second, the swale will be much less likely to erode in the center line right from the outset; and third, if a bioretention filter is placed beneath, it will encourage downward migration of the water into the soil and sand. The stone size shall be based upon the maximum design flow (10 year frequency storm event) to be conveyed and shall be installed to a depth equal to the design flow depth for a water quality storm. The stone shall be embedded flush with the parabolic water way surface. The sizing nomograph may be found in the Standards for Soil Erosion and Sediment Control in New Jersey.

## Pretreatment

As with all other filtering practices, pretreatment is necessary to extend the practice's functional life, as well as to increase the pollutant removal capability. This is usually accomplished through several means, depending on the location of the swale in relation to outfall pipes and impervious areas. A small filter strip, an excavated forebay (or plunge pool) at the point where concentrated collected runoff enters the channel, or a pea-gravel diaphragm at the end of a parking lot providing sheet flow to the swale. These components will settle some of the heavier sediments and preserve the integrity of the parabolic cross section, reducing sediment bars that alter swale flow characteristics. The forebay volume should be equal to .05" per impervious acre of contributing drainage.

## Bioretention Enhanced Swale Design Criteria:

A enhanced swale provides greater water quality benefits by having a bioretention filter installed under the center line of the channel. This type of swale provides some of the same benefits of a larger bioretention filter: infiltration, filtration, pollutant adsorption, and biological pollutant breakdown. In some cases, making the enhanced swale stormwater conveyance system also an effective water quality filter will be cost effective and reduce the need for other treatment BMPs.

The key part of the swale is the excavation of the center line area of the parabolic cross section, and construction of a 'layer cake' filter constructed using the following criteria:

- 36" deep
- top width of 4 – 8 feet
- bottom width of 3 – 6 feet

The filter is layered as follows, bottom-to-top:

- 6" diameter perforated PVC piping on bottom meeting AASHTO M-278 specification, outletting at a stable location, and with a small animal guard at the end

- 6" thick  $\frac{1}{2}$  - 1" diameter gravel layer on bottom meeting AASHTO M-43 specification
- Sand layer over gravel 18" thick meeting ASTM C-33 specification
- Sand/organic matter mixed layer to top. Sand shall meet ASTM C-33 specification; organic matter shall consist of leaf compost, organic peat, or equivalent.
- In stone center swales, the sand layer may be reduced to allow for the depth of the larger stone, and to preserve the depth of the sand/organic layer.

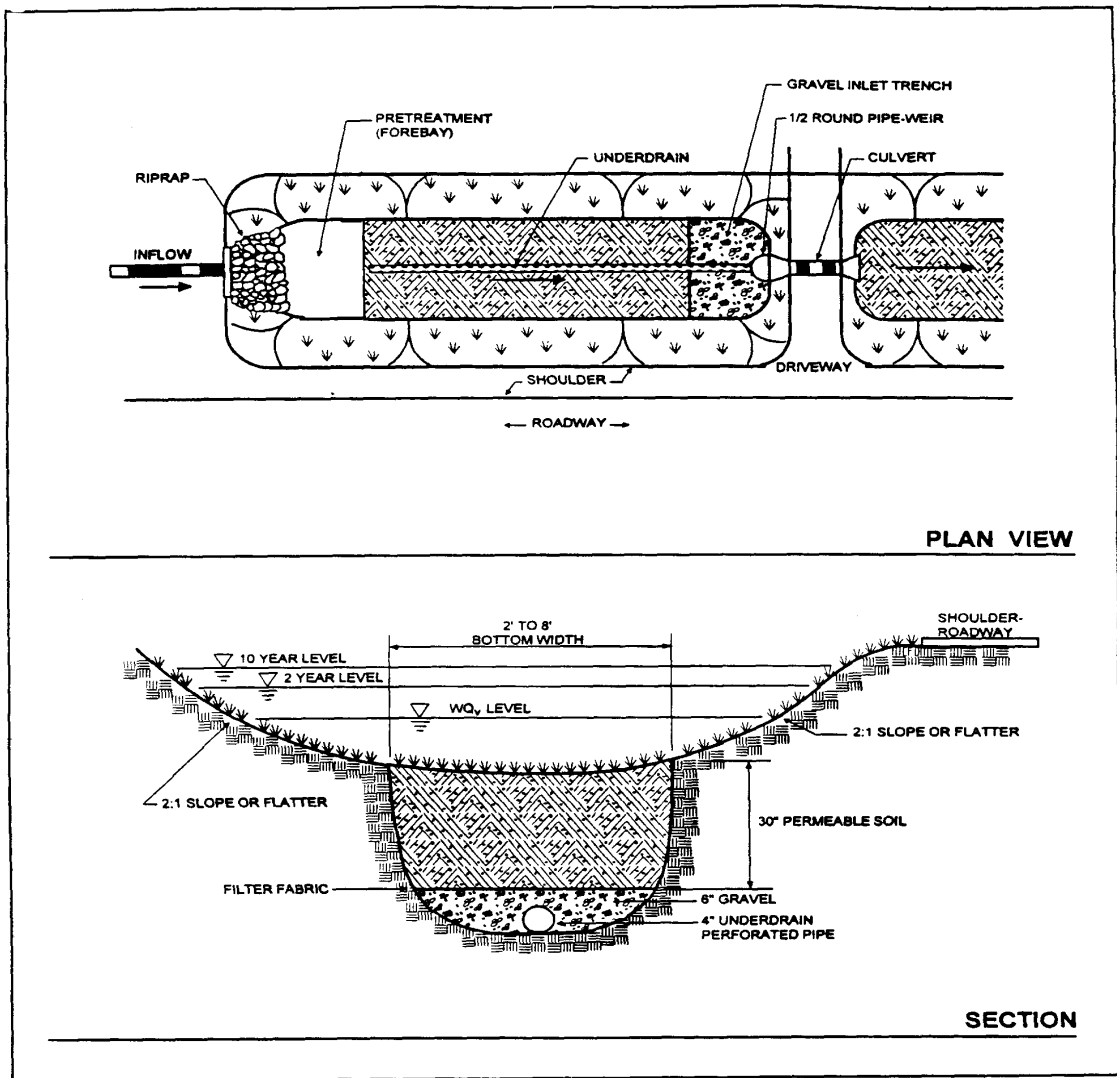


Figure 2. Typical Bioretention design

Source: State of Maryland Dept. of Environment

**After the swale vegetation has been established for at least one full year,**

a series of gravel berms may be placed that extend across approximately 3/4 of the design top width and to a height sufficient to match the Water Quality Volume elevation. The berms should be spaced about 100 - 150 ft. apart. The gravel should be clean and sized to meet AASHTO M-43, 2" diameter at minimum, up to 4" diameter. The purpose for the berms is to enhance settlement and filtration of solids and increase infiltration. Infiltration conditions within the channel must allow for complete drainage within 72 hours. An energy dissipation pad should be included on the downstream side in the channel to prevent scouring of the channel. The pad should consist of 4"- 6" diameter rip rap, extending the width of the berm, and 4 - 6 feet downstream.

### Swale Vegetation Establishment

A permanent cover in the swale shall be established using perennial grasses adapted for the soil and moisture conditions at the site. Refer to the following references from the appendix for grass varieties and establishment criteria:

1. Standards for Soil Erosion and Sedimentation Control in New Jersey (Revised 1999):
  - a. Standard for Permanent Vegetative Cover for Soil Stabilization
  - b. Standard for Permanent Stabilization with Sod
2. USDA - NRCS Field Office Technical Guide
  - a. Standard 412 Grass Waterway
  - b. Standard 342 Critical Site Planting

### Operations and Maintenance

1. Pretreatment Area
  - The pea gravel diaphragm, filter strip, and forebay, if applicable, should be inspected annually for clogging, and the sediment removed.
2. Bioretention sand/organic layer: channel
  - This layer should be checked for erosion if no stone center is in place.
  - Sediments should be removed from this filter
3. Enhanced swale channel
  - Check for and repair erosion. Fill gullies to grade with 2"-4" diameter stone
  - Remove accumulated sediments when they begin to affect flow characteristics or if 20% of the original design capacity has been lost, whichever is first.
4. Vegetation
  - Grass should be mowed on a regular basis. Generally, grass height should be kept within 3 – 6 inches.
  - Grass health and thickness should be inspected annually. Any deficiencies should be addressed without use of fertilizers and pesticides whenever possible.